

TECHNICAL REPORT  
NATICK/TR-82/045

# **EFFECT OF HOLDING TIME AND TEMPERATURES ON THE QUALITY OF PRECOOKED FROZEN MEALS**

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**OCTOBER 1982**

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NATICK/TR-82/045	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EFFECT OF HOLDING TIME AND TEMPERATURE ON THE QUALITY OF PRECOOKED FROZEN MEALS		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER NATICK/TR-82/045
7. AUTHOR(s) Betty A. Davis and Mary V. Klicka		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Natick Research and Development Laboratories Food Engineering Laboratories Kansas Street, Natick, MA 01760		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 1L162724AH 99AA-083
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Natick Research and Development Laboratories Operations Research Systems Analysis Office Natick, MA 01760		12. REPORT DATE 19 October 1982
		13. NUMBER OF PAGES 17
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES  MX Food Service Support, AF 83-7		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) PRECOOKED FROZEN FOODS      SENSORY EVALUATION TEMPERATURE      MENUS HEATING      OVENS QUALITY      FOOD PACKAGING MEALS-HEAT-HELD      MEALS-HEATED		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  The feasibility of heating precooked frozen meals and maintaining them hot for six or eight hours at 71°C until they were consumed was determined. The sensory quality of the meals and the dependability of a commercial holding oven were also investigated in this study.  With the exception of the Sliced Beef and Gravy meal, all other meals tested (Veal Parmesan, Fried Chicken, Salisbury Steak and Turkey with Gravy) were judged acceptable in sensory quality by a technological panel based on a 9-point quality scale.		

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20. ABSTRACT (cont'd)

The commercial holding oven proved to be dependable because it allowed a maximum of 16 meals to be held at 71°C for six or eight hours.

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## PREFACE

The Food Engineering Laboratory (FEL) was requested by Operations Research/Systems Analysis Office (ORSAO) to determine the feasibility of heating and holding precooked, frozen meals at 71°C for six to eight hours for the MX Missile Food Service System (FSS). The Experimental Kitchens Branch of FEL was subsequently assigned the following responsibilities:

- a. To evaluate the dependability of a commercial holding oven (Koolatron).
- b. To determine the feasibility of heating and holding precooked frozen meals for six to eight hours.
- c. To evaluate, using a technological panel, the sensory quality of meals following initial heating and after holding.

The research described in this paper was performed under FEL support to MX Missile FSS, AF 83-7, cost code number 23125004098.

The authors wish to acknowledge the cooperation of the following individuals:

Mr. Richard Bernazzani, Food Systems Equipment Division, FEL, for supplying the Koolatron Holding Oven and associated equipment.

Mrs. Christine Eames, Ms. Karen Conca and Ms. Kelly Townsend of the Experimental Kitchens Branch who contributed to making this an effective study.

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# EFFECT OF HOLDING TIME AND TEMPERATURE ON THE QUALITY OF PRECOOKED FROZEN MEALS

## INTRODUCTION

As part of USAF 83-7, Design of MX Missile Food Service System, there is a need to address the feeding requirements of small teams who will be remotely located from fixed dining facilities. These teams will range in size from two to fifteen people. They will normally be dispatched from the Area Support Centers (ASC) following the breakfast meal to remote work locations for periods of up to 12 hours (including travel time to and from the ASC). Due to the distance between the remote duty location and the ASC (up to 55 miles) and to remote duty time (up to 12 hours), a minimum of one meal must be provided at the work site. Various alternatives to feed hot and cold meals to these remote teams are under consideration. One possible alternative is to have these teams/individuals depart from the ASC with hot food — and to keep the food hot for six to eight hours until it is consumed. The feasibility of this alternative is examined in this report.

A review of the literature indicated that others have studied the effect of holding foods hot for extended periods of time. Hansson et al.<sup>1</sup> and Dagerskog et al.<sup>2</sup> held meat patties up to four hours. Their results were conflicting. Hansson observed little or no effect on the sensory properties of heat-held meat patties. Dagerskog, to the contrary, reported a significant decrease in sensory quality during heat-holding of reheated meat patties.

Jonsson<sup>3</sup> found that the holding time of cooked potatoes must be reduced to prevent penetration of oxygen. This study was conducted to test the effect of holding time and temperature on the quality of precooked frozen meals using a meat, vegetable, starch and dessert item.

## MATERIALS

The purpose of this study was to determine the feasibility of heating precooked frozen meals and maintaining the temperature of the meals for six to eight hours until consumed and to determine the reliability of the Koolatron Holding Oven. Also using a technological panel, heated meals (controls) and heat-held test meals were evaluated for sensory quality.

<sup>1</sup>E. Hansson, H. Olsson, I. Bosund and I. Rasmussen. *Näringsforskning*, 16, 106, 1972.

<sup>2</sup>M. Dagerskog, B. Karlström and N. Bengtsson. *Proceedings of the 22nd European Meeting of Meat Research Workers*. 1976.

<sup>3</sup>L. Jonsson. *Studies on vitamin retention in steamed potato during warm-holding in air and in a nitrogen atmosphere. Näringsvårdesförändringar I. Livsmedel Hanterade I Storhushall*, 1980.



The following materials were used in support of this project:

**Meals:** A total of 170 commercially produced precooked frozen meals (34 each of five different meal menus) were purchased from a local source to support this test. Each meal menu contained an entree, a starch component, a vegetable, and a dessert component. The purchase order for these meals stipulated that all like meals must be from the same production lot. Compliance with this request was assured by ascertaining that all like menus had the same lot number. The meals procured for this test are listed below, identified by the meal entree:

- a. Turkey with Gravy
- b. Fried Chicken
- c. Veal Parmesan
- d. Sliced Beef with Gravy
- e. Salisbury Steak

The meals were packed into disposable, four-compartment, rectangular aluminum trays with a crimped-on aluminum foil cover.

**Holding Oven:** Koolatron Holding Oven (with Power Adaptor), Model #P54  
Koolatron Industries Limited, Barrie, Ontario Canada

**Oven Rack:** A rack constructed of expandable metal (aluminum) was specially designed and fabricated to fit the Koolatron Holding Oven by the Food Service Equipment Division (FSED), Food Engineering Laboratory (FEL).

**Convection Oven:** GE Convection Oven (One-speed Fan)  
General Electric  
Chicago Heights, IL

**Thermometer and Thermocouple:** Fluke Digital Thermometer with Thermocouple Attachments, Model #2176A  
John Fluke Mfg. Co., Inc.  
Everett, WA

## METHOD

A preliminary test was carried out to determine the heating time required for the holding oven to reach the desired temperature (71°C or above) with and without the oven rack. The air temperature of the kitchen was recorded and found to affect the heating rate of the oven. It was determined that the Koolatron Holding Oven with the specially designed rack took approximately 2-1/2 hours to reach 71°C. The rack was designed to hold 16 samples of precooked frozen meals and to help distribute the heat evenly in the oven. The Koolatron Holding Oven is lightweight and easily connected to a vehicle generator.

For each of five tests, 16 identical, precooked frozen meals were removed from the freezer ( $-18^{\circ}\text{C}$ ), placed in a convection oven, and heated to  $71^{\circ}\text{C}$  according to directions on the package. The heated meals were then placed in a Koolatron Holding Oven and held for six or eight hours. Initially, two meals (Turkey with Gravy and Salisbury Steak) were held six hours, but no significant change was noted in the overall quality of the meals when compared to their control counterparts. The remaining three meals (Sliced Beef with Gravy, Veal Parmesan, and Fried Chicken) were then held eight hours to determine if this increased heat-holding treatment affected the meals. Thermocouple probes from a Fluke Digital Thermometer were inserted in three meals randomly chosen from the lot of meals. These three meals were then placed on different rack positions in the oven. Air and holding oven temperatures were monitored.

Approximately 1-1/2 hours before the test, an additional 16 meals of the same menu and from the same lot being held in the Koolatron Holding Oven were removed from the freezer ( $-18^{\circ}\text{C}$ ) and heated in the convection oven for 45 minutes. These meals to be used as controls were placed in a steam table pan and allowed to cool down to  $71^{\circ}\text{C}$  before serving. Every effort was made to assure that temperatures of both the control and the heat-held meals were similar at the time of serving.

### Sensory Panel Evaluation

The sensory evaluations were conducted by the Experimental Kitchens Branch using a panel of 16 technical personnel. The same 16-member panel was used throughout the study. To the maximum extent possible, the chosen panelists were experienced in evaluating the sensory quality of the precooked meals procured for military use. Control and test (heat-held) meals were coded and presented to the testers in a balanced random order. Components of both meals were identified by name. Sample size was a complete meal, served hot. Five independent tests were conducted to evaluate the five different precooked frozen meals. Each panelist rated the meal components for appearance, odor, flavor, texture and overall quality, using the descending 9-point quality scale indicated on the Food Quality Evaluation Form, Figure 1 (where 9 = excellent, 1 = extremely poor). In addition, the panelists indicated whether they would accept or reject the meal. Sensory panel data for each attribute for each different meal component were collected and analyzed separately to evaluate the effect of the heat-hold treatment. The Duncan Multiple Range Test was used to statistically analyze the data.<sup>4</sup>

## RESULTS AND DISCUSSION

The results of the preliminary tests to determine the effect of the presence of a specially designed rack on the temperature of the holding oven indicated that with the rack present, the holding oven took an hour longer to reach  $71^{\circ}\text{C}$  than when the rack was absent (Table 1).

<sup>4</sup>R.G.D. Steel and J. H. Torrie. *Principles and Procedures of Statistics*, 1st Edition, McGraw-Hill, 1960.

TESTER _____ (1-18)									
PRODUCT _____ (20-45)									
INSTRUCTIONS: Please indicate number for quality scores in the box and make comments in the remaining space. Disregard the small numbers on this form; they are for data processing.									
<div style="display: flex; justify-content: space-between;"> <span>REJECT</span> <span>BORDERLINE</span> <span>ACCEPT</span> </div>									
Extremely Poor 1	Very Poor 2	Poor 3	Below Fair Above Poor 4	Fair 5	Below Good Above Fair 6	Good 7	Very Good 8	Excellent 9	

SAMPLE (47-49)	APPEARANCE (55)	ODOR (61)	FLAVOR (67)	TEXTURE (73)	OVERALL QUALITY (79)

STSNL Form 964  
1 Jul 74

**FOOD QUALITY EVALUATION**

EDITION OF 1 MAY 74 WILL BE USED UNTIL EXHAUSTED.

Figure 1. Food Quality Evaluation Form

From these results, it was estimated that it would take two to three hours for the empty oven with a rack to reach the desired holding temperature. However, when a heated meal was placed in the oven with the rack, the oven heated faster and retained its internal temperature better than when a heated meal was placed in the oven without a rack (Table 2).

**Table 1. Temperature Changes in Holding Oven During Heating**

Oven with Rack (°C)	Oven without Rack (°C)	Room (°C)	Time in Minutes
24	24	23	Initial
29	31	23	5
33	34	23	10
36	38	23	15
44	47	23	30
48	53	23	45
53	59	23	60
62	69	24	90
68	73	25	120

**Table 2. Effect of Preheated Meal on the Temperature of the Holding Oven**

Oven with Rack (°C)	Oven without Rack (°C)	Room (°C)	Time in Minutes
66	70	26	After meal is put in
78	71	26	15
77	72	24	30
77	73	23	45
76	74	23	60
76	75	23	120



Where the outside door was opened during a test, it was noted that a change in the kitchen temperature appeared to alter the oven temperature. Evidence of this is documented in Table 3. This leads us to believe that the temperature outside affects the internal temperature of the holding oven. However, it is thought that with heated meals in the oven, the effect of the external temperature would not cause a noticeable change in the temperature of the oven.

**Table 3. Koolatron Oven Temperatures After Opening the Kitchen Door**

Oven with Rack (°C)	Oven without Rack (°C)	Room (°C)	Time in Minutes
** 60	73.4	25.4	75
** 59.6	73.4	25.4	90
* 59	73	25	105
* 57	73	23	120
* 56	71	22	135
* 56	71	22	150
* 56	71	21	165
* 55	70	21	180
* 54	69	21	195
* 54	68	21	205
** 54	69	21	220
** 55	70	21	235
** 55.6	71	22	250

\*Kitchen door was opened.

\*\*Kitchen door was closed.

Figures 2, 3, and 4 show the Koolatron Holding Oven with power adapter and specially designed rack.

The results of the sensory evaluation of each meal, Table 4, indicates that in general each component in the Sliced Beef with Gravy meal held eight hours rated significantly lower than its control meal counterpart.

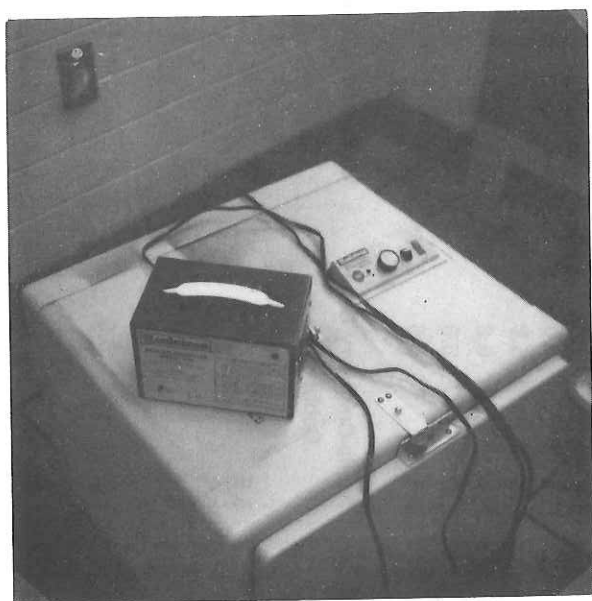


Figure 2. Koolatron Oven with Power Adapter

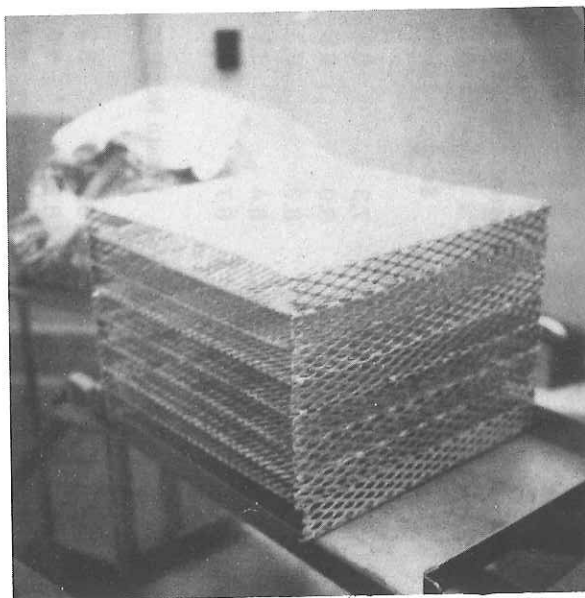


Figure 3. Specially Designed Rack for Koolatron Oven



Figure 4. Koolatron Oven with Rack and Adapter

**Table 4. Effect of Holding at 71°C on the Sensory Quality of  
Precooked Frozen Meal Components  
(Mean Ratings, N = 16)**

Sensory Attribute	Control	Held 8 Hours	Control	Held 8 Hours	Control	Held 8 Hours	Control	Held 6 Hours	Control	Held 6 Hours
	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$	$\bar{X}$
	Sliced Beef with Gravy		Veal Parmesan		Fried Chicken		Turkey with Gravy		Salisbury Steak	
Appearance	6.2	* 5.6	6.6	6.3	6.2	6.2	6.8	6.6	7.3	6.9
Odor	6.3	5.7	6.4	6.2	6.4	5.9	6.4	6.6	6.9	6.6
Flavor	6.2	* 5.1	6.1	6.1	6.2	5.7	6.6	6.2	6.8	6.3
Texture	6.1	5.6	5.9	5.8	5.9	5.4	6.4	6.0	6.4	6.1
Overall Quality	6.1	* 5.4	6.1	5.9	6.1	5.6	6.6	6.3	6.7	6.2
	Whipped Potatoes		Spagetti		French Fries		Whipped Potatoes		Potato Nuggets	
Appearance	6.1	* 4.9	6.4	6.6	4.4	3.9	6.0	5.8	6.9	6.3
Odor	6.1	* 5.2	5.6	5.6	4.7	4.4	5.9	* 5.3	6.5	* 5.6
Flavor	6.4	* 4.9	5.4	5.5	4.1	3.8	6.1	* 5.3	6.4	* 5.4
Texture	6.2	5.2	5.1	5.5	4.3	3.9	6.2	6.0	6.1	* 5.3
Overall Quality	6.2	* 5.1	5.1	5.5	4.4	3.9	6.0	* 5.2	6.4	* 5.5
	Peas and Carrots		Green Beans		Corn		Peas		Mixed Vegetables	
Appearance	6.7	* 5.4	5.6	5.6	5.4	5.9	6.1	5.5	6.6	* 5.4
Odor	6.4	* 5.6	5.9	5.7	6.1	6.0	6.6	* 5.8	6.8	* 5.8
Flavor	6.5	* 5.2	5.1	4.8	5.6	5.6	6.7	* 5.6	6.6	5.9
Texture	6.6	* 5.4	4.9	4.8	5.3	5.6	6.8	* 5.9	6.7	* 5.6
Overall Quality	6.4	* 5.4	5.1	4.9	5.4	5.4	6.6	* 5.6	6.6	* 5.3
	Apple-Cake Cobbler		Apple-Cake Cobbler		Apple-Rasin Cake Cobbler		Apple-Cranberry Cake Cobbler		Apple-Cake Cobbler	
Appearance	6.4	* 5.3	5.5	5.3	4.7	5.4	5.6	5.3	5.6	5.5
Odor	6.6	* 5.5	5.6	6.0	5.9	5.7	6.4	6.3	6.4	6.3
Flavor	6.1	* 5.4	5.0	5.4	5.1	5.3	6.1	5.9	5.9	5.4
Texture	6.1	* 4.8	4.9	4.5	5.2	5.1	5.7	5.2	5.2	4.9
Overall Quality	6.1	* 4.7	4.8	4.7	5.0	5.1	5.9	5.5	5.4	4.9

\*Asterisk denotes a significant difference between control item and test item ( $p < 0.05$ ) Duncans Multiple Range test.

The control Beef with Gravy entree rated "below good" in all attributes whereas the heat-held product was judged only "fair" to "above fair" in the various attributes. These findings are in agreement with those of Dagerskog et al.,<sup>5</sup> who reported a decrease in sensory quality during heat-holding of meat patties. The panelists rated all other heat-held entrees (Veal Parmesan, Fried Chicken, Turkey with Gravy, and Salisbury Steak) and their respective controls at essentially the same levels. These findings agree with those of Hansson et al.,<sup>6</sup> who found a rather small effect on sensory properties (appearance, odor, flavor, and texture) of meat patties. All ratings for the Veal Parmesan and Fried Chicken entrees were in the "above fair" to "below good" range. Ratings for both the Turkey with Gravy and Salisbury Steak entrees were slightly higher being in the "below good" to "good" quality range.

The vegetable components of the Sliced Beef with Gravy, Turkey with Gravy and the Salisbury Steak meals (peas and carrots, peas, and mixed vegetables) all were judged to have undergone significant overall quality changes after being held for six to eight hours. For these vegetables, control products rated "below good" to "good" whereas the heat-held products dropped to "fair" or "above fair" in quality. The quality attributes of the green beans and the corn in the Veal Parmesan and the Fried Chicken meals were not adversely effected by the heat-hold treatment. The french fries in the Fried Chicken meal judged "below good" to "fair" in all quality attributes, were not any the worse from holding for eight hours; but the potato components of the other meals did not stand up well to being heat-held six or eight hours. Panelists noted the presence of an oxidized or metallic taste in the potato products. Jonsson<sup>7</sup> observed that in heat-held potatoes, the time must be reduced to prevent penetration of oxygen. Ratings for the control potato products, except for french fries, rated "below good" to "good" while the heat-held products rated only "fair" or "above fair" in overall quality. The spaghetti component of the Veal Parmesan meal was not adversely affected by holding eight hours at 71°C.

For the most part, fruit cobblers were judged "fair" to "below good" in all quality attributes. The apple cobbler in the Sliced Beef with Gravy meal rated significantly lower than its control counterpart in all quality attributes after heat-holding eight hours at 71°C, while the quality of the same product in the Veal Parmesan Meal was judged to be unchanged by the identical heat-hold treatment. The panelists commented on great variation in appearance of the cobblers. Some panelists indicated that the cobblers seemed overbaked. Thus the differences noted may reflect product variability rather than the effect of the heat-hold treatment.

In addition to determining if there were any significant differences between the mean ratings of the respective components of heat-held and control meals, the panelists were also asked to judge the overall meal and indicate whether or not the meal as a whole was acceptable.

<sup>5</sup> See reference 2.

<sup>6</sup> See reference 1.

<sup>7</sup> See reference 3.



The panelists indicated they would accept all control meals. The results obtained with the Sliced Beef with Gravy meal, in which all components of the test meal rated significantly lower than the control, were supported by this meal being rejected. In both the Turkey with Gravy and Salisbury Steak meals, the vegetable and starch items rated significantly lower than those in the control meals. However, panel members indicated they would accept both meals. From Table 5, it is seen that four of the five precooked frozen meals were found to have acceptable quality even after being heat-held for six or eight hours. Even though in three of the five meals the vegetable and starch items did not react well to being heat-held, these meals were still accepted. Nonetheless more work should be done on heating and holding vegetable and starch type items. Table 5 provides a summary of the sensory data on each component of all five of the precooked frozen meals tested.

**Table 5. Summary of Effects of Holding on the Overall Quality of Frozen Meal Components**

Meal	Entree	Starch	Vegetable	Dessert	Overall Meal
Sliced Beef with Gravy	S	S	S	S	Reject
Veal Parmesan	NS	NS	NS	NS	Accept
Fried Chicken	NS	NS	NS	NS	Accept
Turkey with Gravy	NS	S	S	NS	Accept
Salisbury Steak	NS	S	S	NS	Accept

S — Significantly different ( $p < 0.05$ )

NS — Not Significantly different ( $p > 0.05$ )

Panelists agreed that the size of the meals was sufficient. Representative portion sizes for each component of the meals are shown in Table 6.

Panelists commented that the aroma of all of the items in the meal blended and that the odor of an individual meal component was not discernible. Blending of odors was probably due to the meals being covered throughout the six- or eight-hour holding period.

During the study, one of the Koolatron Holding Ovens malfunctioned. Electricians concluded that the malfunction was caused by moisture in the electrical circuits. It was noticed that panelling for the holding oven was not moistureproof. This defect in the holding oven makes it unsuitable for all climates since moisture causes the mechanical parts to rust.

**Table 6. Weights of Individual Portions of Precooked  
Frozen Commercial Meals**

Meal Portion Weight (Only One Meal was Weighed to Obtain Portion Weights)

Item	Weight (g)
Salisbury Steak with Brown Onion Gravy	215
Peas and Carrots	30
Potato Nuggets	61
Apple Cake Cobbler	96
Veal Parmesan in Tomato Sauce	268
Spaghetti in Tomato Sauce	88
Green Beans	33
Apple Cake Cobbler	70
Sliced Beef with Gravy	162
Whipped Potatoes	78
Peas and Carrots	33
Apple Cake Cobbler	88
Fried Chicken (3 pieces)	215
French Fries	47
Corn	38
Apple-Raisin Cake Cobbler	75
Turkey with Dressing and Gravy	268
Peas	44
Whipped Potatoes	91
Apple-Cranberry Cobbler	72

### CONCLUSIONS

After testing the concept of heating a meal and holding it for six or eight hours, certain conclusions can be drawn about the feasibility of this concept and the dependability of the Koolatron Holding Oven:

a. Concept of heating and holding a meal is marginally acceptable because:

1. The aroma of each meal component becomes indistinguishable from the other. This phenomenon is similar to the mingling of aromas that occurs with food on covered insulated trays used for foodservice.

2. Even though some of the vegetable items did not hold up well to being heat-held, overall, most of the meals retained acceptable quality.

b. The Koolatron Oven performed well during the test:

1. The specially designed rack allowed a maximum of 16 meals to be held hot in the commercial holding oven.

2. After reaching the desired temperature (71°C), it was possible to maintain this temperature for six or eight hours.

3. There was only a single malfunction because of moisture in the electrical circuits, but this may preclude the oven from being sufficiently dependable for diverse military applications.

### **RECOMMENDATION**

Additional research needs to be done to determine what foods can withstand being heat-held and for how long. More work should also be done on the Koolatron Holding Oven to ensure its effective performance in moist climates.

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